Silicon thermite!

Chances are that you know more or less what silicon actually means and that you've heard of the term thermite but that you've not heard both words used in the same sentence.

Silicon is of course the bluish tinted metal (well, to be precise, metalloid) without which putting this post up would be impossible. It's incredibly widely used for its semi-conductor properties but other uses include various alloys, notably with iron (steel) and aluminium. Silicon is the second most abundant element (after oxygen) in the Earth's crust. It's mainly found as common sand and other quarts based minerals, which chemically are made up mostly of silicon dioxide (SiO_2).

As regards thermite, even if you haven't heard of this, chances are that you've seen a thermite reaction in action without even knowing. Thermitereactions use aluminium metal as the reducing agent of the oxide of another metal. During the reaction the mixture of metal oxide and aluminium causes the aluminium to "capture" the oxygen from the metal oxide, leaving behind the pure metal and aluminium oxide. The worded reaction is thus:

metal oxide + aluminium --> metal + aluminium oxide

Several metal oxides can thus be treated to obtain the metals from their oxides (typically ores), such as iron (Fe), manganese [not to be confused with magnesium, Mg] (Mn), cobalt (Co), chromium (Cr), copper (Cu), titanium (Ti), silicon (Si) and quite a few others.

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Many of these reactions proceed with massive heat generation and the metal then usually forms in the liquid state and solidifies at the bottom of the reaction crucible. The most famous of all thermites is undoubtedly the iron thermite in which iron (III) oxide (Fe_2O_3) is reacted with aluminium powder. You can see the kind of fireworks that reaction produces in the photo at the top of this article. Molten iron (melting point 1568 C, 2800 F!) is formed. It's this phenomenal heat that is exploited in incendiary bombs (at least during the Blitz of London by the Luftwaffe) because this kind of temperature is high enough to set just about anything on fire!

The iron thermite reaction is also used to mend cracks in tram tracks: the molten iron then welds the tram tracks back together *in situ*. You may have seen this process at work in your hometown.

Besides aluminium other reducing agents can be used to free pure metals from their oxide based ores. Lithium (Li), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbon (C) and many others are used in various reductions. Collectively, extractions of metals from their oxides by means of reducing agents and heat, are known as pyrometallurgy. The most used pyrometallurgical process used in the world is the extraction of iron from iron ore by means of cokes (carbon) in blast furnaces, for the production of steel.

Although the production of high grade (i.e. very pure, needed for semi-conductor purposes) silicon does not involve pyrometallurgy in the strict sense of the word, there is nonetheless a silicon thermite reaction, which involves reacting silicon dioxide, aluminium powder and sulphur together. This reaction allows you to produce small amounts of relatively pure silicon metal, in your backyard!

A "pure" silicon thermite, based only on silicon dioxide and aluminium, is very hard to ignite and tends to fizzle out quickly. All thermite reactions require good ignition by means of locally applied strong heat, usually obtained by setting off a small amount of ignition mixture, but silicon thermite mixtures require extra aluminium and sulphur to ensure a self-sustaining reaction and to avoid fizzling.

A good starting point for the mixture is the following formula: silica:aluminium:sulphur = 9:10:12 (parts by weight).

Here, by silica is understood a source of silicon dioxide. Common beach sand is used most often. Grinding this sand down in a mortar and pestle or ball mill grinder (a rock grinder e.g.) will produce a finer, hotter burning mixture but grinding isn't strictly speaking necessary.

By aluminium is meant a suitably fine grade of aluminium powder. I prefer to use a 400 mesh grade. Again, the finer the powder the faster the reaction will proceed and the hotter it will run.

For sulphur, a garden grade is suitable.

I've ran many thermites in the past, including silicon thermites and I ran another one today: 300 g of ground sand/400 mesh aluminium powder/garden sulphur.

Here's the assembly before ignition: the mix is contained in an old cache pot and embedded in dry sand in a steel bucket. The sand is acting as an insulating blanket and heat sink. In the middle of the thermite mix is a bit of ignition powder (a mixture of potassium chlorate, aluminium powder and sulphur) and a piece of magnesium ribbon acting as a fuse. This is lit by means of a small propane burner or a hot lighter.

This reaction ran so fast and hot I had no time to take photos! It burned like hell for about 30 seconds, producing a white-hot flame the size of a small rugby ball!

At the end of the reaction, a white hot, molten mass of aluminium oxide, aluminium sulphide and silicon metal was left at the bottom of the (cracked) cache pot. This indicates the melting point of alumina (2054 C, 3729 F) was reached comfortably!

To see what a slower silicon thermite using the same reaction mixture looks like, click here and play the video, near the bottom of the page.

Here's the cache pot crucible and bucket separated after the reaction. The cache pot is badly cracked due to thermal shock (only specialist materials will survive the thermal onslaught without cracking or melting), but held together by the resolidified mix of aluminium oxide and aluminium sulphide.

The mix of aluminium oxide and sulphide is called slag. To the right: the slag, broken up and hammered down, "mining" for silicon metal globules.

And the "finished product" some silicon metal globules, compared to a 1 p coin...

If you'd like to run a silicon thermite but have no prior experience, I strongly suggest to download this *.pdf, which contains detailed instructions(and much needed advice on health and safety).

For other experiments on pyrometallugy, visit my pages on making homemade bronze!

Here's my post on copper thermite!

Here's an alternative silicon thermite: **a sulfur-free silicon thermite**.